

Lunar Reconnaissance Orbiter: (LROC)

Audience

Grades 6-8

Time Recommended

1-2 hours

AAAS STANDARDS

- 1B/1: Scientific investigations usually involve the collection of relevant evidence, the use of logical reasoning, and the application of imagination in devising hypotheses and explanations to make sense of the collected evidence.
- 3A/M2: Technology is essential to science for such purposes as access to outer space and other remote locations, sample collection and treatment, measurement, data collection and storage, computation, and communication of information.

NSES STANDARDS

Content Standard A (5-8): Abilities necessary to do scientific inquiry:

- c. Use appropriate tools to gather, analyze and interpret data.
- d. Develop descriptions and explanations using evidence.
- e. Think critically and logically to make relationships between evidence and explanations

Content Standard E (5-8): Science and Technology:

- c. Technology is essential to science, because it provides instruments and techniques that enable observations of objects and phenomena that are otherwise unobservable due to factors such as quantity, distance, location, size, and speed. Technology also provides tools for investigations, inquiry, and analysis.

MATERIALS

- Image of the near side of the Moon
- Class example transparency of specific location on the Moon (Moscoviense Region)
- Images of specific locations on the Moon for student groups
- Transparencies of specific locations on the Moon (three different regions, wide-angle and close up images of each region)
- Image Analysis worksheets (one per student)
- Image Analysis Transparency (class example)
- Rulers
- Calculator
- Chart paper or blackboard/ whiteboard for recording student responses

Exploring the Moon through Image Analysis

Learning Objectives:

- Students will classify lunar features based on their characteristics.
- Students will use the scale of a lunar image to determine the actual size of certain features.
- Students will explain how a 2D image can provide information about the surface of the Moon.

Students will explore what they can learn from lunar images taken by a camera on the LRO spacecraft (LROC) and how these images can help to select a future landing site.

Preparation:

Make sure to have all the materials ready, prior to the lesson.

Background Information:

For more background information on the LRO spacecraft mission:

<http://lunar.gsfc.nasa.gov>.

Additionally, please see the LROC instrument website:

<http://lroc.sese.asu.edu>.

Procedure:

1. Ask students to share their ideas about what they would expect to see in images of the Moon that might help them determine whether or not the area would make a good landing site.
2. Show the transparency of the near side of the Moon. Ask students to describe the surface. Do they see any areas that look like safe landing sites? Can they see enough to make a decision about where to land? Note: students should recognize that we would need to look at more detailed images to make decisions about where we should land.
3. Explain to the students they will be working in groups to evaluate a possible landing site by investigating some of the features of specific sites on the surface of the Moon.
4. Introduce the mission of LROC (Lunar Reconnaissance Orbiter Camera). Explain that LROC is one instrument on the Lunar Reconnaissance Orbiter (LRO). It is taking very high-resolution images of the Moon so that we can learn more about the lunar surface. Teachers, if you would like more background information on LROC check out <http://lroc.sese.asu.edu>.

Ask students how this spacecraft will help NASA? Explain to students they will be working with real images from the LROC instrument on-board the LRO spacecraft.

5. Display the Moscoviense Region #1 image (wide-angle) as a class sample (a transparency is recommended). Locate feature A. Record its coordinates, measure the image in centimeters, observe the scale, calculate the actual size, and describe the feature demonstrating the process for each task. Locate feature B on the other Moscoviense Region #2 image (close up). Record its coordinates, measure the image in centimeters, observe the scale, calculate the actual size in kilometers, and describe the feature demonstrating the process for each task. **Point out to students that the different images use different scales for distance. It is important that we pay attention to the scale for the image we are working with.**
6. Distribute the Image Analysis worksheet.
7. Describe and demonstrate the work of the following jobs using the projected image:
 - a. **Map technician** (determine location and size of feature)
 - b. **Observer** (describes the feature in their own words)
 - c. **Mathematician** (calculate size of the feature based on the scale)
 - d. **Recorder** (records the responses from the other group members)
8. Divide students into groups of four, designating a particular role above (if it is not possible to have four per group, roles noted above can be combined as needed and completed by one student).
9. Groups will gather information about the four, labeled features on their Moon image, as well as five features of their choosing. Have students label the additional features with letters (E-I) directly below the feature they choose. Once data has been collected on each of the nine features, the whole group will work together to classify the objects based on their size (small, medium, large) and define each category.

Note: the feature “A” on both images of each region is the same feature but at a different resolution (one is wide-angle, the other a close up). Be sure NOT to reveal this to students at this point, as they will discover this later on.

10. Give each group of students one of the six images. Please note that you may need to give the same image to more than one group. Note that different groups will look at different site regions at different resolutions (wide-angle/close-up).
11. Students should work as a team for 15-20 minutes to identify features in their image and record information/ complete the Image Analysis worksheet.
12. Put up Moscoviense Region transparencies (#1 wide-angle and #2 close-up) for a class example. Point out that both images are of the same site region but with a different resolution. The close up image includes much more detail about a smaller area. **Teacher can now reveal that feature “A” is the same in both images.** Note: in the Moscoviense Region # 2 image, “A” refers to the brighter half circle on the left side of the image that fills more than half of the image area.
13. Put up Humboldtianum Region transparencies (#1 wide-angle and #2 close-up).
14. Have the groups who worked with the Humboldtianum Region (both images #1 and #2) share their classification system (what constitutes small, medium and large) and then point out one feature in each class. The teacher should record information about which features the Image #1 (wide angle) group and Image #2 (close-up) group defined as small, medium, and large in a chart on butcher paper, blackboard or whiteboard.
15. Repeat this comparison for the Goddard Region and Reiner Region transparencies.
16. Look at the recorded information about what constitutes small, medium, and large for each region and particular resolution. Lead a discussion on the similarities and differences within and between resolution type and region.

17. Ask the students to reflect on how each of these images can play a role in selecting a future lunar landing site. What information do the images provide? What are they lacking? Share with students that when Apollo 11 astronauts were landing on the Moon, a site had been selected that appeared to be smooth and appropriate for landing. Interestingly, as they approached the site, they found the area was covered in boulders that would make it impossible to land. The boulders were not visible on the lunar maps available at the time. Astronaut Neil Armstrong was forced to steer the spacecraft to avoid the boulders.

(Optional video resource: interview clips with astronaut Buzz Aldrin about the experience:

<http://www.history.com/videos/buzz-aldrin-on-approach-to-moon#how-the-lunar-landing-site-was-chosen>).

LROC images help us create a more detailed map of the Moon so we can avoid these difficulties.

18. Return to the initial question of how these lunar images help us to understand various scientific understandings related to the surface of the Moon.



IMAGE ANALYSIS

Group Members: _____

Region Site: _____

Image #: _____

Study the lunar image. Know who will undertake the following roles explained by the teacher: recorder, map technician, mathematician, and observer. Select features in the image to study. For each feature, complete the following information:

1. Locate the feature on the image.
2. Fill in each part of the chart (Recorder)
3. Measure the size of the feature (diameter for circles and longest side for other shapes) in the image (Map Technician)
4. Calculate the actual size of the feature (Mathematician)
5. Describe the characteristics of the feature (Observer)
6. After finishing steps 1-6 for each feature, classify the features as small, medium or large (Whole Group)

Feature	Coordinates	Size in Image (cm)	Multiplier for cm to km	Actual Size (km)	Description	Classification (S, M, L)
A			x	=		
B			x	=		
C			x	=		
D			x	=		
Choose and label 5 additional features:						
E			x	=		
F			x	=		
G			x	=		
H			x	=		
I			x	=		



After studying the image, based on your observations answer the following questions:

1. Based on what you have observed in your image, how would you describe this area of the Moon?
2. Do you think there are any parts of this area that would make a good landing site for spacecraft or probes? Be sure to support your response with evidence from the research your group completed.
3. After hearing what your classmates learned about other lunar landing sites, which do you think might be the best for landing? Be sure to support your response with evidence.
4. What questions does your group still have about your image? Where could you get information to help you answer those questions?

TEACHER SCORING GUIDE

Assignment: Image Analysis

Student Name(s): _____

Date: _____

Performance Indicator	0	1	2	3	4
Students completed all sections of the worksheet.					
Students' math is careful and accurate.					
All descriptions of image objects are complete and are accurate.					
Students support their responses with appropriate evidence.					
Students make reasonable conclusions about site selection.					
Point Total					

Point total from above: _____ / (20 possible)

Grading Scale:

A = 18 - 20 points

B = 16 - 17 points

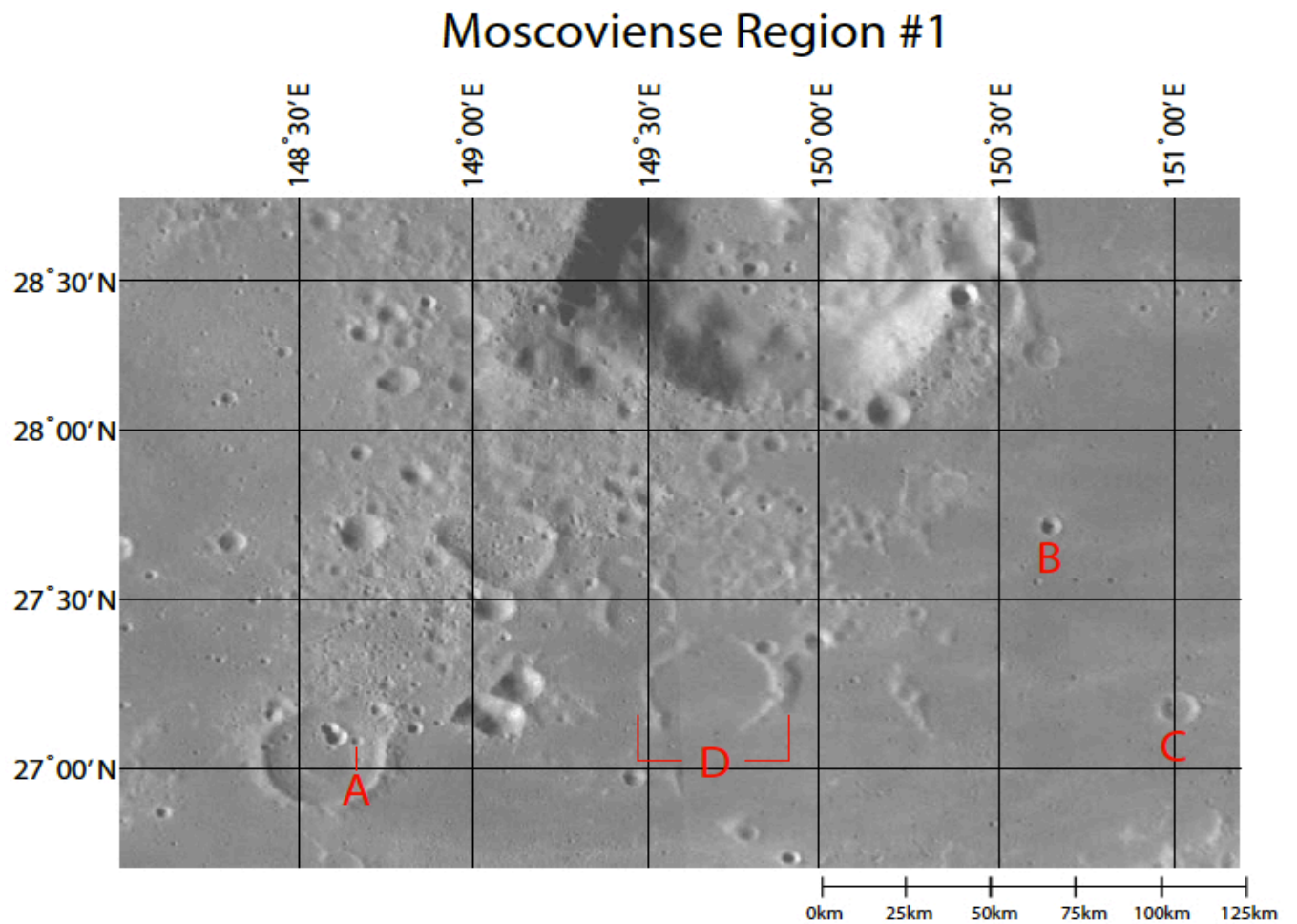
C = 14 - 15 points

D = 12 - 13 points

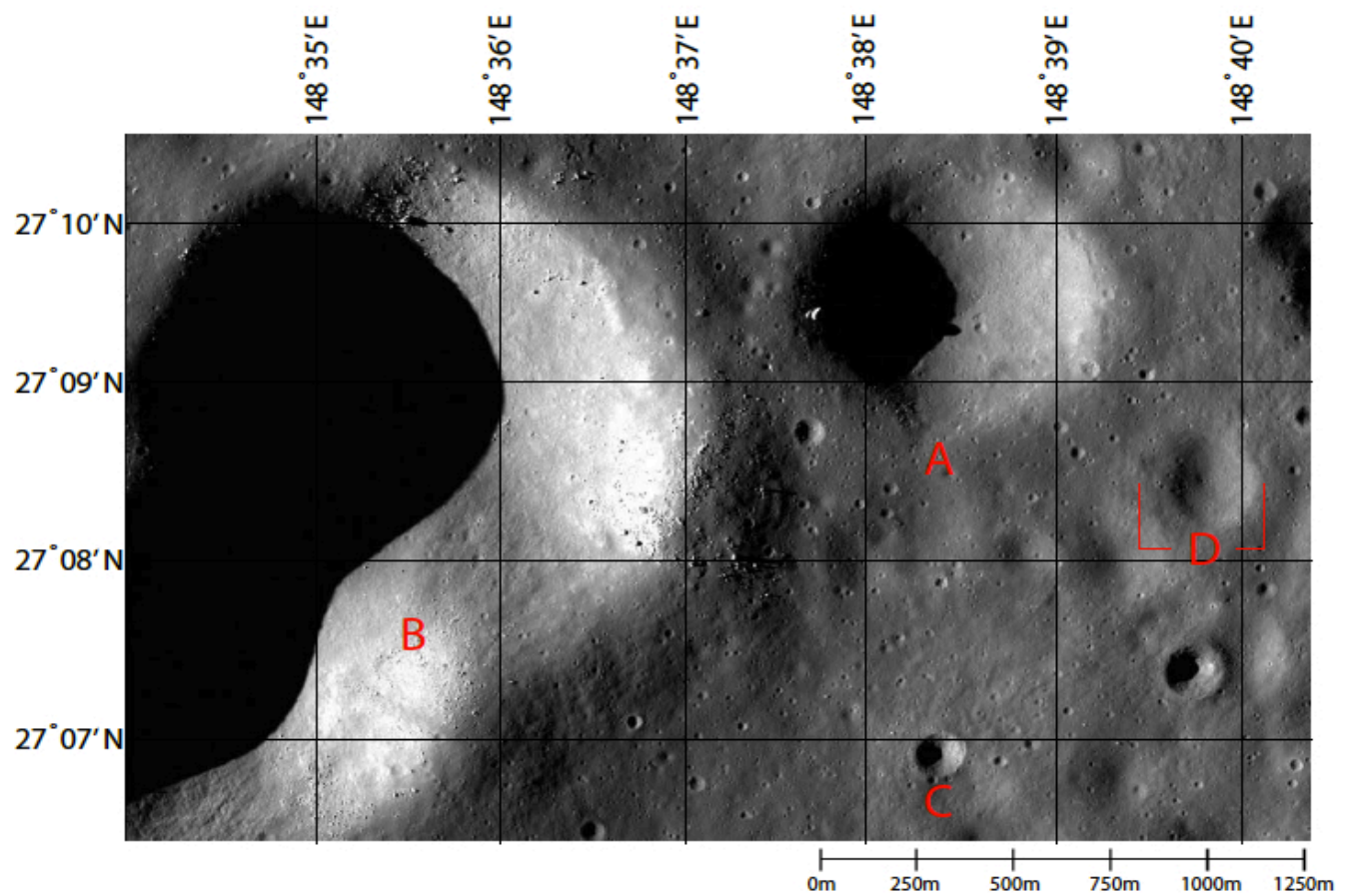
F = 0 - 11 points

Grade for this Assignment: _____

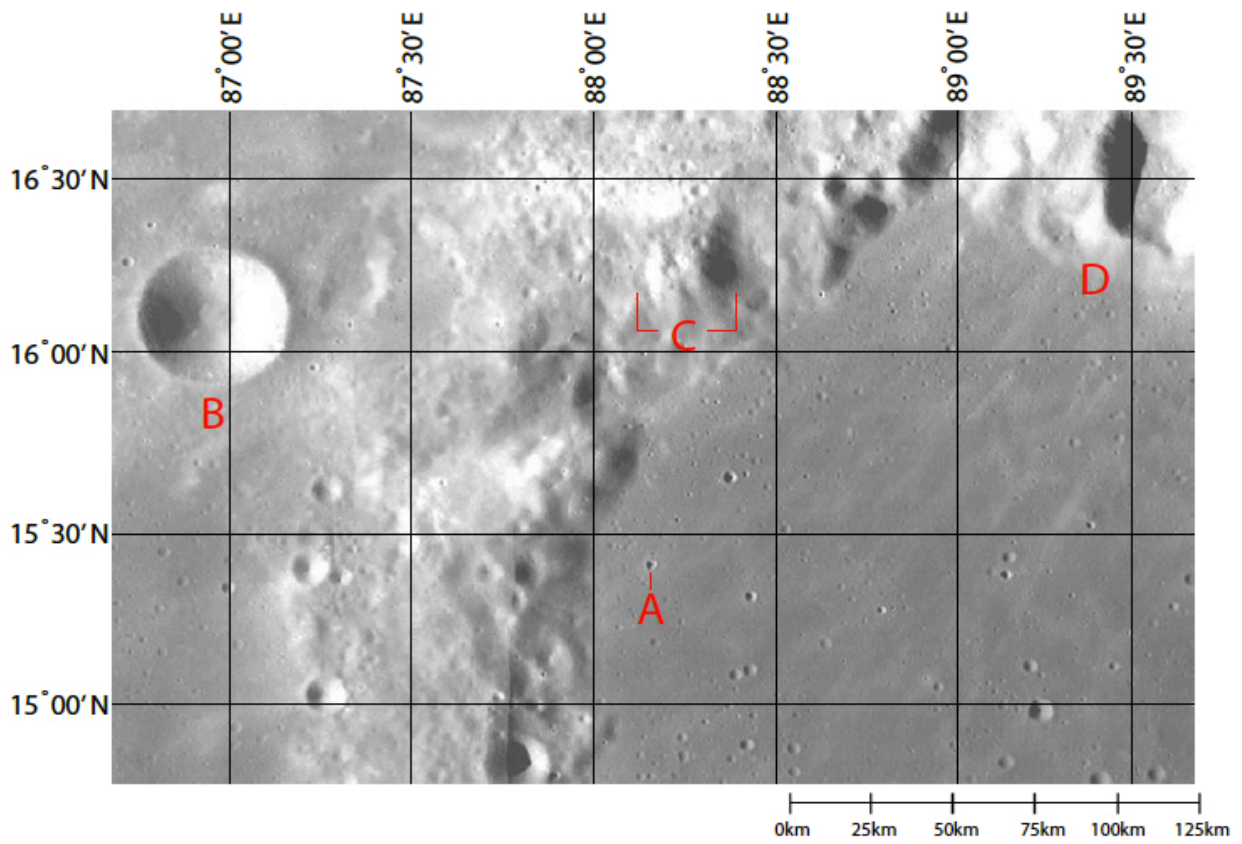
SUPPLEMENTAL IMAGES/ MATERIALS/ RESOURCES:



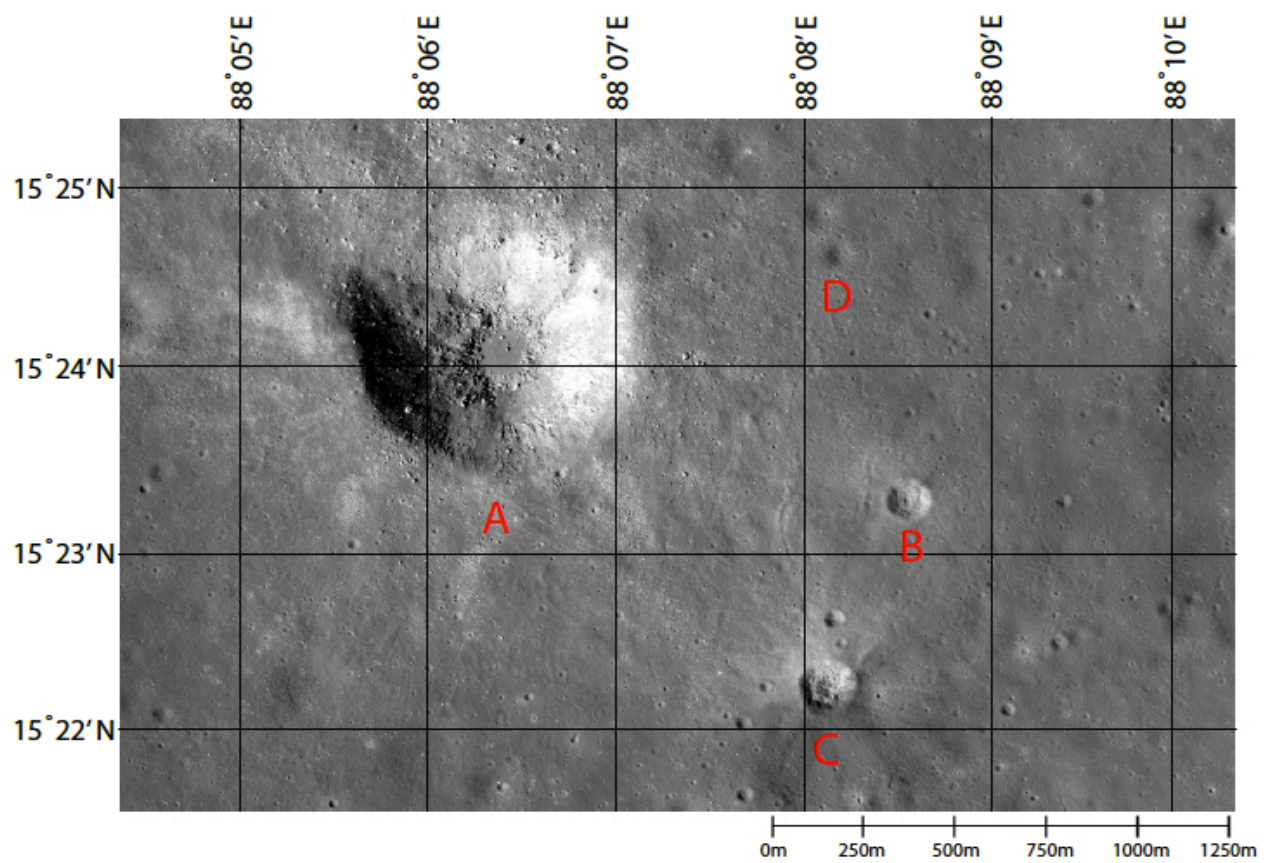
Moscoviense Region #2



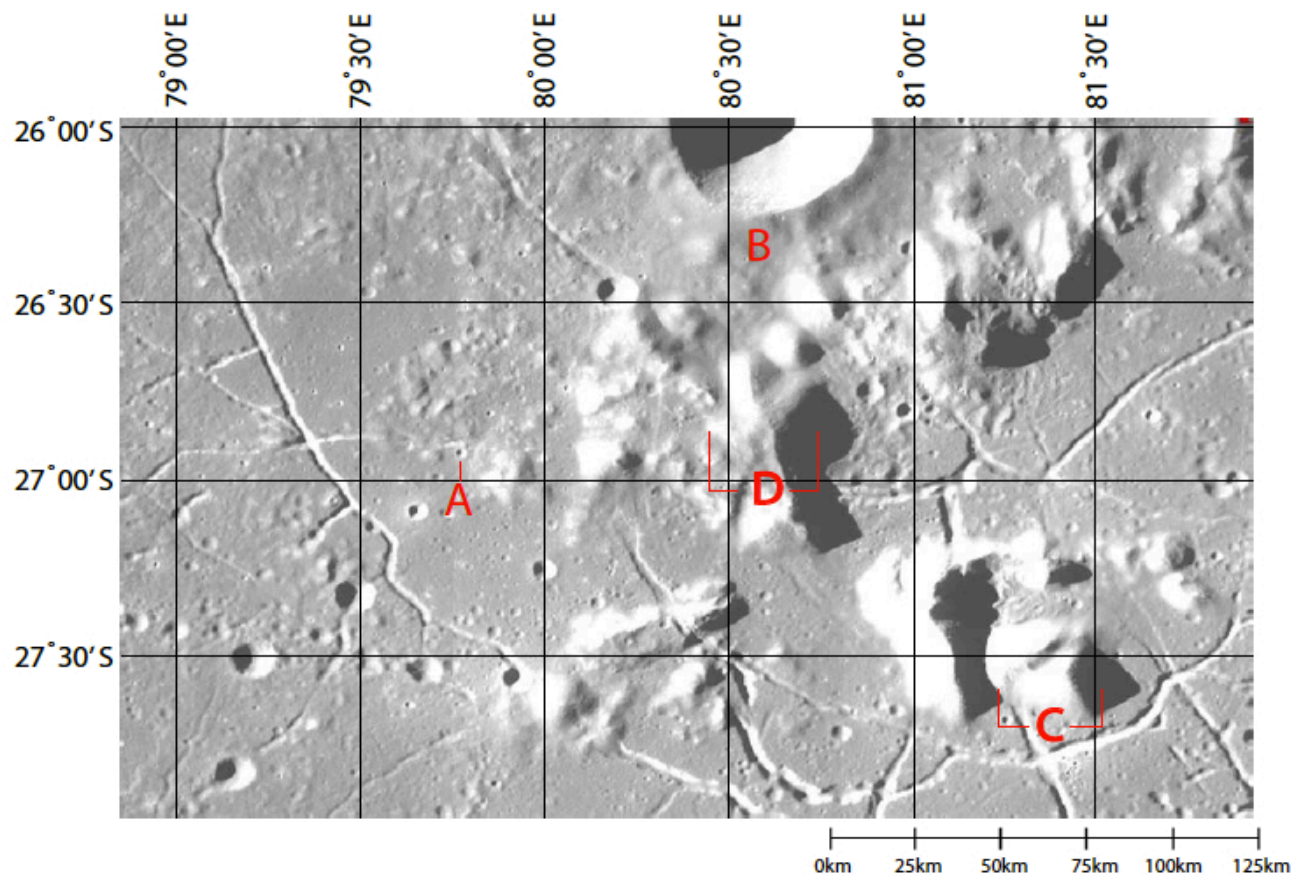
Goddard Region #1



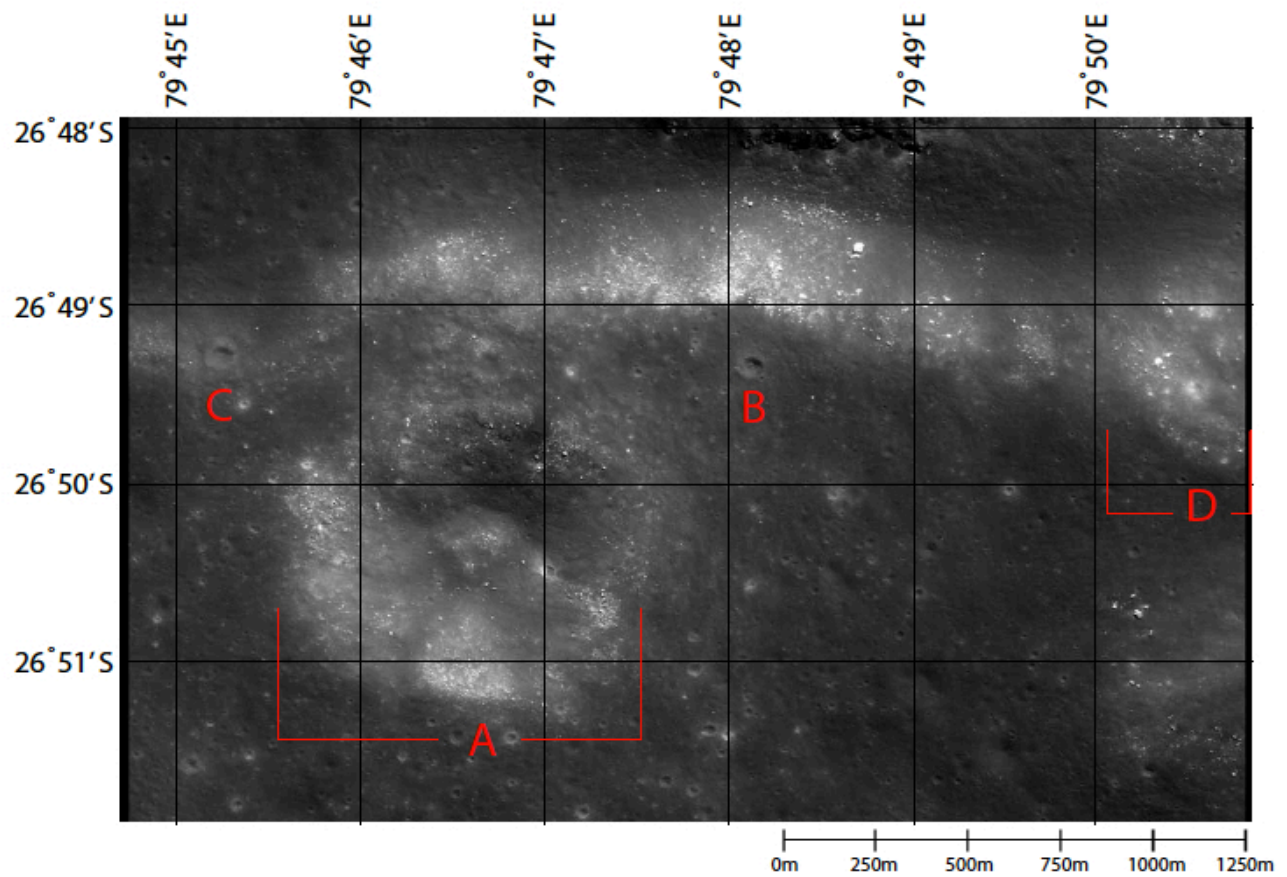
Goddard Region #2



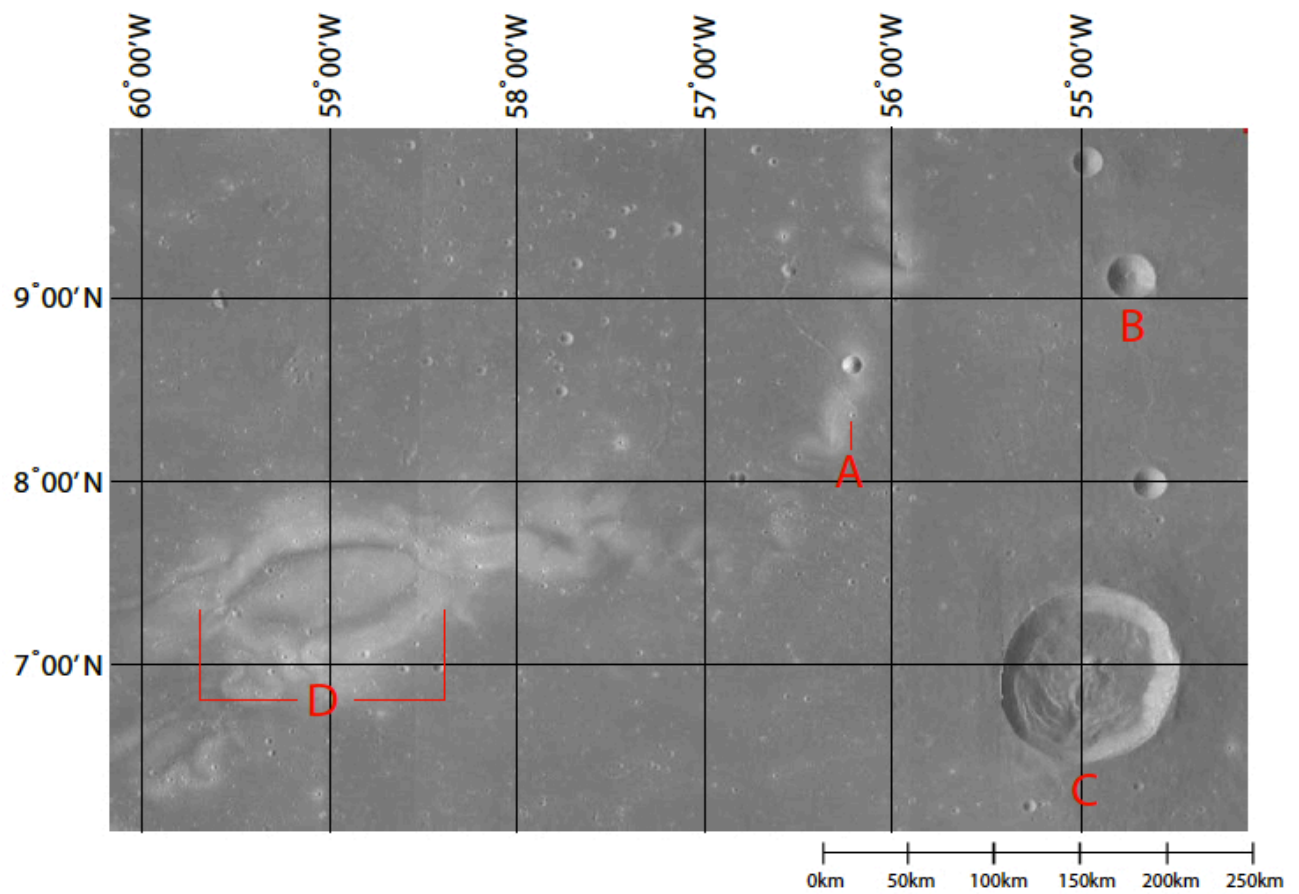
Humboltanium Region #1



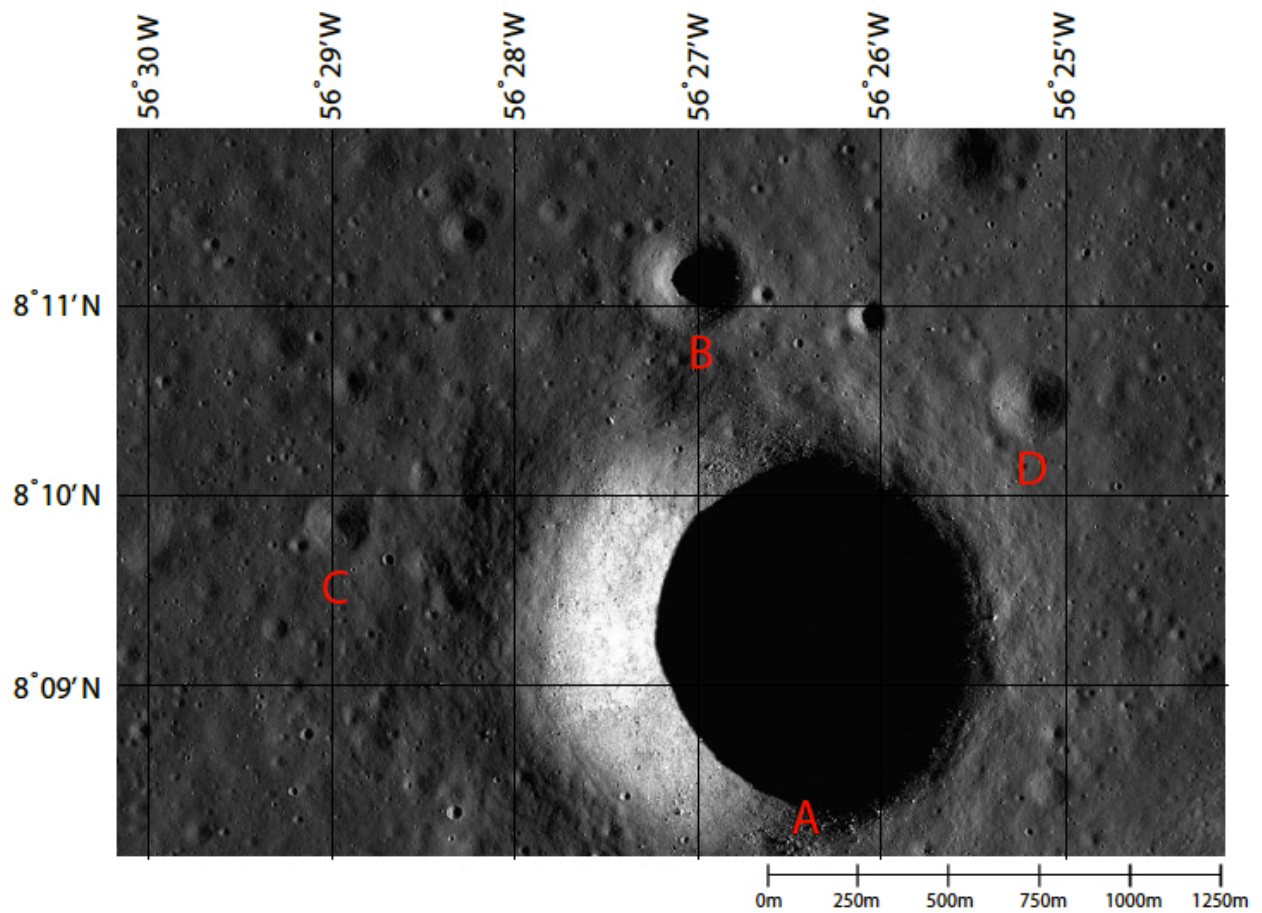
Humboltanium Region #2



Reiner Region #1



Reiner Region #2



Assessment:

Review the Image Analysis worksheets for evidence of complete and accurate descriptions of objects in the image. Review the landing site selection question for evidence and reasonable conclusions. See attached rubric for a suggestion of how to grade your students' work.

Extension Activities:

You and your students can help scientists manage and classify images taken by the LROC instrument through a citizen science program called Moon Zoo (<http://www.moonzoo.org>). Students have an opportunity to learn about different features on the Moon and classify images based on their own scientific observations of those features.

Continue to examine other sites on the Moon's surface with a neat tool called "Quickmap" on the LROC website:
<http://target.lroc.asu.edu/da/qmap.html>

This tool will take you from a mosaic of wide angle images of the Moon all the way in to corresponding narrow angle images, so students can really explore in great detail over the whole surface of the Moon!